ASSESSING TECHNOLOGICAL CAPABILITY

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INTRODUCTION

The purpose of technology forecasting in this context is to assess the capability of technology to meet the current and forecasted future needs of the customers. This requires in all cases the translation of customer needs, quite often expressed in terms of benefits, to specifications for price, function, and form, often thought of as attributes, at the product level. These in turn must be converted into performance criteria for the technology. For example, throughput of traffic over a city's road system may ultimately depend upon the processing speed of microprocessors in remote locations. If this is a factor controlling the development of that part of ITS (Intelligent Transportation System), then the speed of microprocessors must be forecasted. In making the assessment of future technological capabilities, there are three questions to be answered. Will the forecasted technology's capability:

- Be sufficient to meet customer needs?
- Be insufficient to meet customer needs?
- Surpass forecasted customer needs?

If the technological capability will satisfy customer needs, no further analysis is required. If it appears that technological capability will fall short of satisfying customer needs, the organization must decide if this is a limitation of the technology or the result of the amount of effort being given to advancing the state of the art. If it is a result of the amount of effort, what effort could the organization put in place that would advance the technology faster than the general market, thereby giving the organization a significant edge? If the capability of technology appears to be in excess of what is required by its application, then the question the organization must answer is, "What new needs is the availability of this technology likely to create?" The organization may also want to assess its own technological capability versus that of the industry. Our technology forecasting techniques facilitate this type of assessment.

FORECASTING TECHNOLOGICAL CAPABILITY

The necessity to forecast technological capability derives from the requirement to fulfill the future needs of the customer. Once customer needs are understood, a logical next step is to discern which of the technologies available are likely to have capabilities to meet the needs at the specified future time in question. Forecasting is, however, more than trying to precisely pinpoint a single parameter. Our former colleague, Ralph C. Lenz, whom many consider to be the father of technological forecasting, was fond of quipping, "It's better to be approximately right than precisely wrong!" Futurist Joseph P. Coates eloquently states, "The burden of the

work and the key to making forecasts credible has increasingly been assumed by the communications process rather than by the more abstract qualities of technical analysis."

For today's environment, technology forecasting should be defined as the process of discovering and communicating probable technical capabilities in order to make better decisions and prevent surprises. Forget the academic exercises and concentrate on discovering the direction, rate, and nature of the changes taking place in the technologies in question. The tools available for accomplishing these tasks fall into four general categories of techniques: surveillance, trend analysis, expert opinion, and integrative. The techniques within the four are aimed at discerning the probable capabilities at the three levels of technology (direct, supporting, and enabling). The types of techniques used and the efforts employed to forecast are dependent on a series of both internal and external factors -- social, political, economic, demographic and scientific driving forces for change. The main reasons for conducting the forecast are to make better decisions, and to prevent surprises.

TECHNIQUES

SURVEILLANCE

For forecasting purposes the surveillance category is made up of three technique (process) areas; scanning, monitoring, and tracking. **Scanning** is the process of looking broadly for events and trends that may imply an impact (threat or opportunity) upon the technical arena of particular interest. The activity is not unfocused, nor is it undirected; rather it is purposeful in effort to skim and detect. An individual who can discipline himself or herself to follow a scanning process can review great volumes of material in very short periods of time. Once potential information or data is detected, monitoring is used.

Monitoring is the process of specifically, and with a defined purpose, following the technological developments in a particular area. Monitoring may be done by an individual or as a team or group effort. Not only are information and data gathered, they are analyzed for meaning and impact and the results communicated in some meaningful way. It is virtually impossible to develop a forecast without using monitoring techniques.

Tracking is the process of carefully and purposefully following a greatly narrowed range of technological development. The frequency of activity is greatly increased in a technological tracking mode. The results of this activity are of immediate value and can be used for both operational and strategic decisions.

TREND ANALYSIS

Trend analysis as a category consists of many, mostly quantitative, techniques. We identify six techniques that have proven to be the more useful overall in business environments. They are precursor developments, trend extrapolation, the Pearl curve, the learning curve, substitution, and multiple substitution.

Forecasting using **precursor developments** can be done when a lead-lag relationship can be established

between two technical areas. This is usually done by observation over a period of years, and establishing causal connections between the technical areas.

Trend extrapolation involves plotting key parameters of technical progress against time. From the results, regular development patterns can be discerned. An initial assumption can be made that the patterns, which are rooted in past developments, can be extended into the future for some period of time. In a large number of technical areas, it has been found that if progress is plotted versus time, the trace is linear on a semilog graph. This would represent a constant percentage rate of change.

The **Pearl curve** - named for the American demographer Raymond Pearl, who used it in demographic forecasting, is one example from a family of growth models. These techniques are often used to describe technological change patterns that resemble organic growth. The slope of the Pearl curve is a function of both the distance to go to the upper limit for growth and the distance already covered.
The **learning curve** is a production-driven performance technique. Its basic premise is that as the number of units produced doubles, the labor hours per unit decrease by a constant factor.

Substitution analysis is used to forecast the rate at which one technology will replace another. The traditional approach involves the simplification of the Fisher-Pry model. This model predicts characteristics loosely analogous to those of biological system growth. Many examples now exist for technology substitution.

Multiple substitution represents an increasingly common situation in which either more than one new technology is substituted for an old one or a single new technology is actually replacing more than one old technology.

EXPERT OPINION

Interviews can be conducted under two basic conditions structured and unstructured. Each type has advantages and disadvantages associated with it. However, given the value of people's time structured interviews are optimal.

Surveys are conducted under many different formats and for many different reasons. They can vary from public opinion surveys administered by organizations such as Gallup to market research surveys done by the likes of Good Housekeeping, Gentlemen's Quarterly, Working Woman or Money magazines. In large part what differs in a survey focused on technology development rather than market research or public opinion is the types of questions asked and who is included in the survey universe. One particular type of survey, the **Delphi**, can be adapted very well to the rigors of obtaining both quantitative and qualitative data.

There are also a myriad of **group techniques** that can be directed to gaining technological information for forecasting purposes. These group techniques may range from the familiar **focus group** to the highly structured and inclusive **morphological analysis**. In many cases groupware and networked computers can be used to facilitate interaction.

INTEGRATIVE

The integrative category of forecasting techniques consists of four technique areas: opportunity analysis, scenarios, cross-impact analysis, and mathematical models.

Opportunity analysis is the integration of multiple technology forecasting techniques within the context of a dynamic market stirred by social, political, economic, demographic and technical driving forces and combined with present and future customer needs and competitive responses. It is our preferred method of forecasting change in the real world.

Scenarios generally present in a narrative form the descriptions of multiple forecasts. They can provide a common context and a vehicle for presentation of very complex concepts and information.

Cross-impact approaches are designed to capture interactions between events or trends and to represent them formally in a cross- interaction model. Mathematical complexities, such as probabilities, can be deftly handled in a cross-impact matrix. With the advent of PCs and spreadsheet software the need to construct expensive models has diminished significantly.

A **mathematical model** uses equations to represent the system in which events occur. It requires significant time and effort to initiate and construct, and maintaining the model with current data is a necessary, yet onerous, task. The value of large mathematical models solely for technological forecasting is negligible in the current environment.

CONCLUSION

All these categories are useful and important to forecasting technological change. The forecaster must continuously update any and all projections as well as assess the impacts that the driving forces for change will have on the development rate and direction of technology.